Chapter4
Recurrent Evolving Systems, Reinforcement Learning and Evolving Automata

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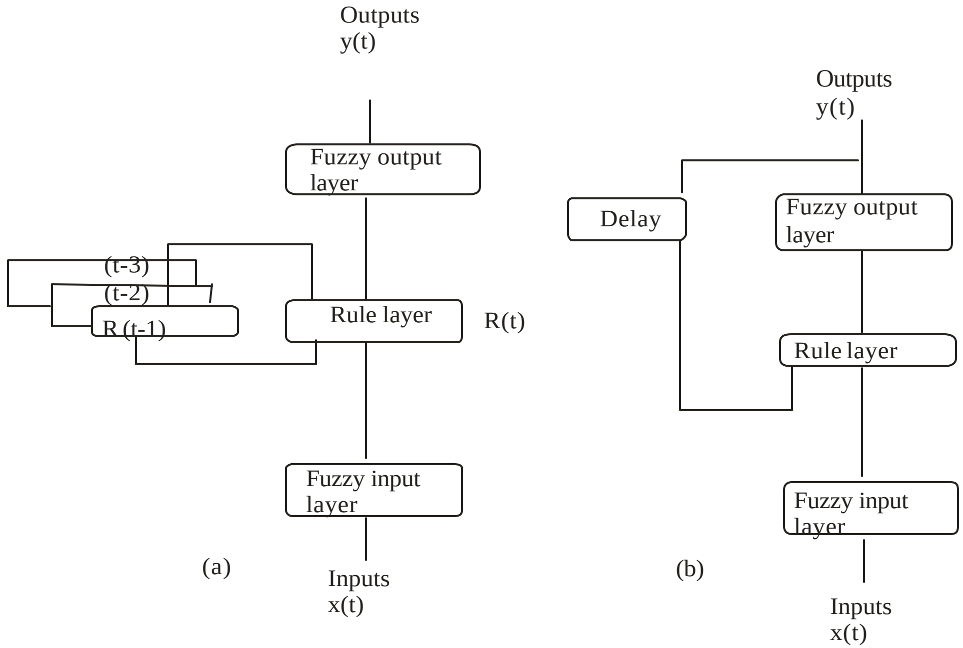
Overview

- Recurrent evolving Connectionist Systems
- Evolving Connectionist Systems and Evolving Automata
- Reinforcement Learning in ECOS

Recurrent Evolving Connectionist Systems

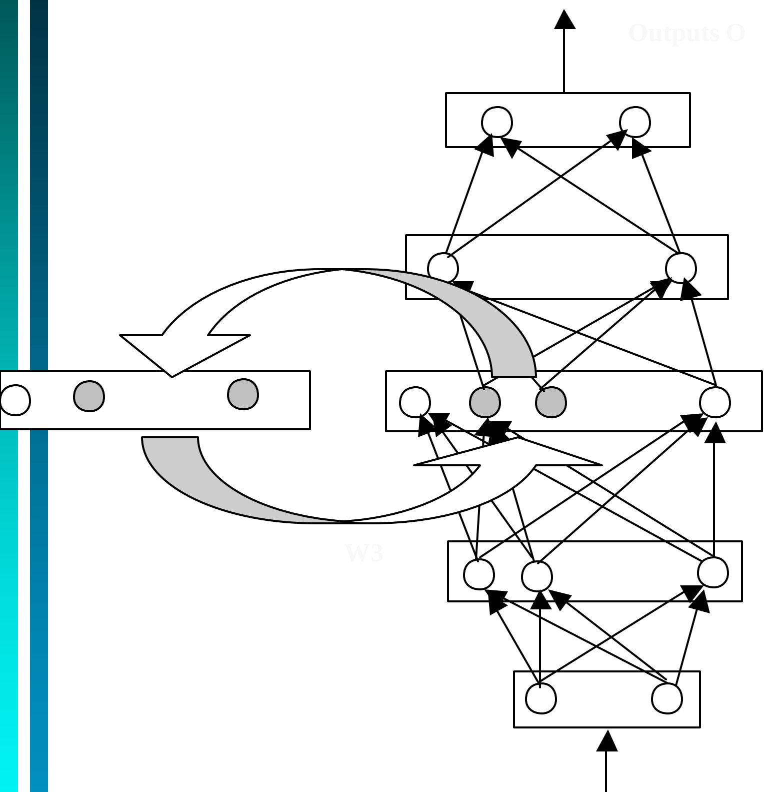
- These systems have feedback connections from hidden or output layers of neurons back to the inputs or to the hidden layer nodes.
- Recurrent structures capture temporal dependencies (not always known in advance) between the presented data examples from the data stream.

Recurrent EFuNN Structures



Two types of recurrent EFuNN structures: a) recurrent connections from the rule layer; b) recurrent connections from the output layer (Fig 4.1)

Recurrent EFuNN for Fuzzy Automata



Recurrent EFuNN for the realiasation of an evolving fuzzy automation.

The transitions between states are captured in the short-term memory layer and

and feedback connections. (Fig 4.4)

ECOS and Evolving Automata

- Finite Automata and Recurrent Networks
  - » Deterministic finite state automaton
  - » Recurrent connectionist architectures, having the feature to capture time dependencies, are suitable techniques to implement finite automata
- Evolving Automata
  - » In an evolving automaton, the number of states in the set S is not defined *a priori;* rather it increases and decreases in a dynamic way, depending on the incoming data
  - » A recurrent EFuNN can realize an evolving fuzzy automaton

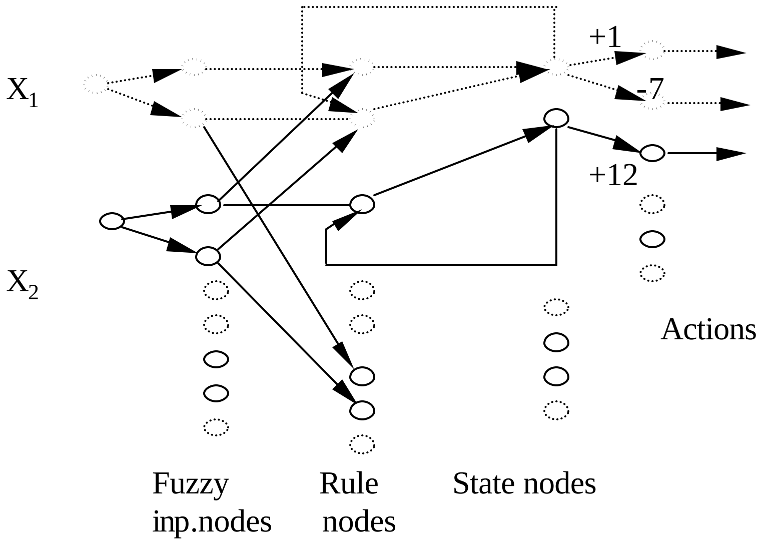
Reinforcement Learning in ECOS

- Based on similar principles as supervised learning, but there is no exact desired output and no calculated exact output error.

- There are several cases in an evolving reinforcement learning procedure:
  - » There is a rule node activated (by the current input vector **x)** above the pre-set threshold, and the fuzzy output node activated the highest is the same as the received fuzzy hint.
  - » Otherwise, there will be a new rule node created and new output neuron (or new module) created to accommodate this example.

- This type of a recurrent EFuNN can be used in mobile robots that learn and evolve as they operate

Recurrent EFuNN



An exemplar recurrent EFuNN for reinforcement learning (Fig 4.5)

Summary

- Methods outlined indicate potential of ECOS for
  - » Learning in a reinforcement mode
  - » Learning temporal dependencies
  - » Realisation of evolving finite automata

Further Reading

- Recurrent structures of NN (Elman, 1990; Arbib, 1995, 2002).
- Finite automata and their realization in connectionist architectures (Arbib,1987; Omlin and Giles, 1994).
- Introduction to the theory of automata (Zamir,1983; Hopkin and Moss, 1976).
- Symbolic knowledge representation in recurrent neural networks (Omlin and Giles, 1994)
- Reinforcement learning (Sutton and Barto,1998).